

Stormceptor[®] Monitoring Results

78th Street Maintenance Facility

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Clark County Public Works Department
Environmental Services Division

Stormceptor[®] Monitoring Results 78th Street Maintenance Facility

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Introduction

A Stormceptor[®] water quality Best Management Practice (BMP) was tested as a possible drywell retrofit option which could meet the need for a treatment BMP at developed sites such as maintenance yards, high traffic areas, and industrial sites.

The Stormceptor[®] replaces a conventional manhole in the storm sewer system and functions to remove oil and sediment from stormwater. A patented high flow by-pass is designed to prevent the resuspension and scour of settled materials during subsequent storm events. CSR Associated is the sole distributor of the Stormceptor[®] stormwater treatment system.

The project was conducted in part under Washington Department of Ecology Centennial Grant Agreement No. G9400261.

Disclaimer: The testing and potential use of the Stormceptor[®] does not constitute an endorsement of its suitability or preference over other BMPs.

Scope

This investigation was limited to testing a relatively small number of water constituents and a small number of rainstorms over a one-year period. Since the number of samples was small, the results are qualified.

Influent and effluent stormwater were tested to calculate pollutant removal. The BMP's performance was compared to the manufacturer's claims and recently published results from other Stormceptor[®] studies. Additionally, pollutant removal was compared to BMPs in the Puget Sound Manual.

As supplementary information, depth of sediment accumulation, particle size distribution, and sediment pollutant concentration were also tested.

Methods

Site Description

A Stormceptor® 1200 was installed at the Clark County Public Works Department, Maintenance and Operations facility located at 4700 NE 78th Street, Vancouver, Washington. The catchment area is part of a high traffic maintenance facility where vehicles and equipment are stored, fueled, washed, and maintained. It includes a covered fueling area with catch basins draining to the storm sewer, a covered wash rack with recycled water, and repair shops. The site is nearly 100 percent impervious area. Figure 1 shows the study site.

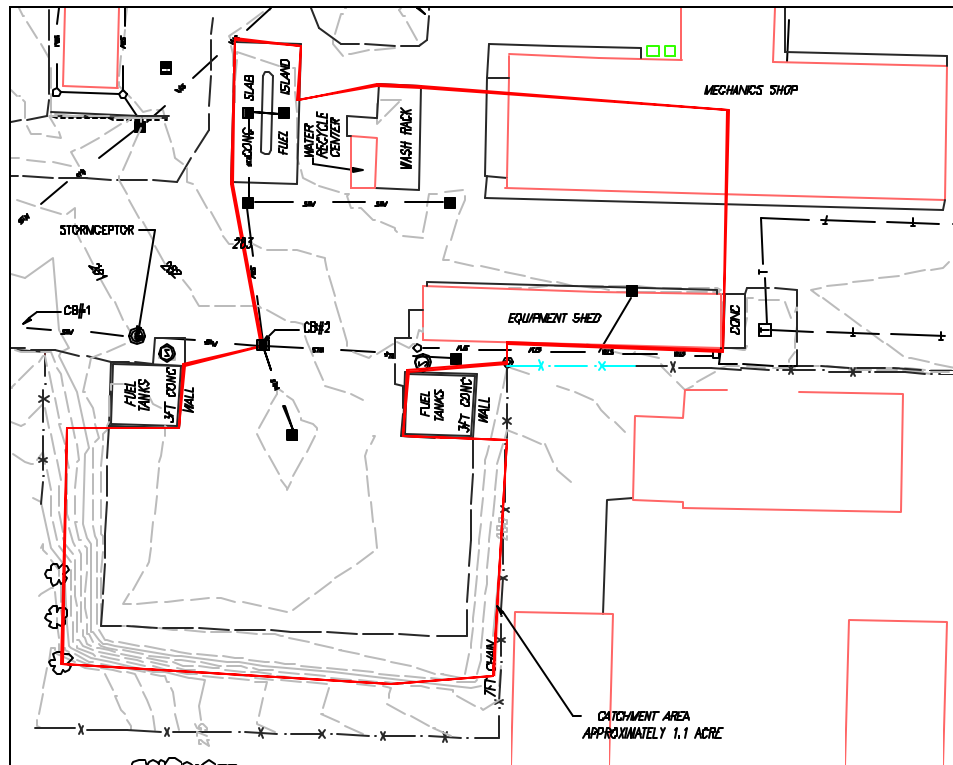


Figure 1. Layout of Stormceptor[®] study site at 78th Street Maintenance and Operations facility.

System Design

The system size was selected based on flow rate. Design considerations consisted of sizing the Stormceptor® based on a catchment area of approximately 1 acre and a desired suspended solids removal efficiency of 60%. Sizing guidelines for Stormceptor® systems rely on the following regression equation:

$$y = 0.3864x + 20.431$$

where y = estimated suspended solids removal (%), and
 x = Stormceptor® sediment storage capacity per unit area (ft³/acre).

The expected peak flows were calculated for the 6-month, 2-year, and 10-year 24-hour design storms using the TR-55 computer program. Rainfall depths corresponding to these design storms are 1.3", 2", and 2.5", respectively. The 6-month rainfall depth was calculated as 67% of the 2-year rainfall depth and corresponds to the Puget Sound Manual (PSM) water quality design storm (Clark County Isohyetal Maps). Based on a catchment area of approximately 1.1 acres, a runoff curve number of 98, and a computational minimum travel time of 6 minutes, the following peak flows were calculated:

$$\begin{aligned}Q_{6\text{-month}} &= 0.30 \text{ cfs,} \\Q_{2\text{-year}} &= 0.47 \text{ cfs, and} \\Q_{10\text{-year}} &= 0.61 \text{ cfs.}\end{aligned}$$

Based on these parameters and guidelines, the STC 1200 with a 110 ft³ sediment storage capacity was installed. The Stormceptor[®] STC 1200 is designed for a maximum treatment flow rate of approximately 0.64 cfs before by-pass. Therefore, the system should treat (not by-pass) all flows less than or equal to the 10-year, 24-hour design storm.

Storm Sampling

Two SIGMA 900 MAX automated samplers were installed to capture stormwater entering and exiting the treatment chamber. A single integral area-velocity flow meter was installed at the downstream location to operate both samplers. A co-axial cable connected the two samplers and enabled the downstream (effluent) sampler to trigger the upstream (influent) sampler. In this way, samples were collected approximately simultaneously from the influent and effluent locations.

The general criteria for sampling a storm were:

1. Rainfall should exceed 0.1 inches,
2. Storms should last more than 6 hours, and
3. There should be at least 24 hours between the last measurable precipitation and the sampled storm.

The samplers were set to collect 24 500-ml samples on a flow interval of 44 cubic feet. By this method, any storm that generated a total runoff up to 1063 cubic feet (~8000 gal) could be sampled in its entirety. This represents approximately 6.5 times the 164 cubic foot holding capacity of the Stormceptor. For reference, a 0.2" rainfall should produce approximately 799 cubic feet (~6000 gal) of runoff from the sample site.

Each sampler held 4 one-gallon glass sample jars. During sampling, each bottle received six 500-ml samples. The sample bottles were composited at the laboratory so that one influent composite and one effluent composite were analyzed for each sampling event.

Influent and effluent composite samples were analyzed at North Creek Analytical (NCA), a Washington Department of Ecology (DOE) certified laboratory located in Beaverton, Oregon. Samples were retrieved from the samplers, kept on ice, and picked up by NCA personnel for transport to the lab within 24 hours of sample collection.

Samples of stormwater runoff entering and leaving the Stormceptor® were collected for six storms between February 1999 and November 1999. Table 1 shows the analytical method and reporting limits used by NCA for each parameter tested.

Parameter	Method	Reporting Limit
TSS (mg/L)	EPA 160.2	10
Turbidity (NTU)	EPA 180.1	0.2
TDS (mg/L)	EPA 160.1	10
TPH (mg/L)	EPA 418.1	0.5
Total Phosphorus (mg/L)	EPA 365.4	0.035
TKN (mg/L)	EPA 351.2	1.0
Total As (mg/L)	EPA 200.8	0.001
Total Cd (mg /L)	EPA 200.8	0.001
Total Cr (mg /L)	EPA 200.8	0.001
Total Cu (mg /L)	EPA 200.8	0.002
Total Pb (mg /L)	EPA 200.8	0.001
Total Zn (mg /L)	EPA 200.8	0.005
Dissolved Cu (mg /L)	EPA 200.8	0.002
Dissolved Pb (mg /L)	EPA 200.8	0.001
Dissolved Zn (mg /L)	EPA 200.8	0.005
Conductivity (umhos/cm)	EPA 120.1	10

Table 1. Parameters sampled, analytical methods, and reporting limits for influent and effluent samples.

The composited samples were analyzed and the results reported as event mean concentrations (EMCs) for influent and effluent samples. Pollutant removal percentage for each storm and pollutant was then calculated as:

$$100(\text{average influent concentration} - \text{average effluent concentration}) / \text{average influent concentration}$$

Overall efficiency of the Stormceptor® was also calculated based on the geometric mean, as follows:

$$100(A-B)/A \quad \text{where}$$

A= geometric mean of all influent samples

B= geometric mean of all effluent samples

Sediment Sampling

Depth of sediment accumulation was measured periodically throughout the sampling program using a sludge bailer. At the conclusion of the sampling program, one sample was analyzed for particle size distribution, percent solids, and pollutant concentration.

The sediment sample was scooped from the Stormceptor[®] using a stainless steel spoon after standing water had been pumped out. Scoops were composited in 1 gallon glass jars. Table 2 lists the constituents tested for the sediment sample.

Parameter	Method	Method Reporting Limit
Total arsenic	EPA 6020	0.500 mg/kg
Total cadmium	EPA 6010A	0.500 mg/kg
Total chromium	EPA 6010A	0.500 mg/kg
Total lead	EPA 6010A	10.0 mg/kg
Total zinc	EPA 6010A	1.0 mg/kg
Diesel range organics	NWTPH-Dx	250 mg/kg
Heavy oil range hydrocarbons	NWTPH-Dx	500 mg/kg
1-Chlorooctadecane	NWTPH-Dx	
Percent solids	% by weight	

Table 2. Sediment Testing Constituents and Methods

QA/QC

Quality assurance/quality control procedures at NCA were performed in accordance with the laboratory's Washington Department of Ecology approved quality assurance manual.

In addition, a field duplicate was collected on March 13, 2000. The sample intake lines from each sampler were mounted adjacent to each other at the downstream (effluent) sampling point and allowed to complete a full 24-sample cycle. The samples were analyzed to assess differences between the two machines.

Results

Limitations

The most significant limitations associated with this project can be attributed to unforeseen difficulties with sampler operation. Over the course of the project, several sample events were affected by sampler problems. Most notably, the distributor arm on the influent sampler jammed on occasion, causing overflowing of bottles and introducing the possibility of sample bias. To counteract the potential for contamination, the sampler bases were thoroughly cleaned between each sampling event. The overall effect of overflow on sample integrity is unknown, but assumed to be minimal.

The other significant problem tended to arise when intense rainfall occurred over a brief time period. At a six-month design storm peak flow of 0.30 cfs, it takes only about 2 1/2 minutes to get 44 cf of flow. Since a typical sample cycle (pre-purge, rinse, purge, sample, post-purge) required approximately 4 minutes to complete, high flow events may have caused the sampler to try to initiate a second sampling cycle before it could finish collecting the first. It appears as though this problem may have caused oversampling by one sampler during some storm events. The result is that the sample times and volumes were not always identical between the two samplers.

The timing and extent of this oversampling during the sampling period was unknown, and therefore introduced the possibility of significant error in the sample collection process.

Censored Data

Censored data (values less than the specified reporting limit) were included in calculations unless otherwise noted in the Appendix data tables. Censored data were entered as 1/2 of the reporting limit.

Storm Description

Table 3 below lists the beginning date for each storm sampling period along with the general antecedent conditions as measured at the WSU Research Extension approximately one mile east of the sample site.

Date	Antecedent Dry Days (< 0.1 inches per day)	24 hour Storm Period Rainfall (inches)
2-February 1999	unknown	0.36
30-April 1999	3	0.11
13-August 1999	5	0.59
5-October 1999	11	0.14
25-October 1999	16	0.42
16-November 1999	3	0.69

Table 3. Storm Description.

QA/QC

Laboratory QA/QC results were reviewed by County staff upon receipt. Chain of custody and laboratory QA results are available on request. Results of the field duplicate sample may be found in the Appendix.

Results for the field duplicate were within the expected range of variability for most constituents. TPH and total dissolved solids showed the largest relative percent difference between the two samples (113.0 and 43.8 percent, respectively). Relative percent difference for the remaining parameters ranged from 5.5 to 27.0.

Stormwater Inflow and Outflow

Event mean concentration data from the influent and effluent of each sampled storm event are contained in the Appendix.

Table 4 shows the influent and effluent median concentrations for each parameter sampled. Table 5 contains the range of values for selected influent and effluent parameters. Table 6 shows the percent removal for each constituent on each sampling date, as well as the median percent removal for all sample events. Table 7 contains the overall removal efficiencies based on geometric mean concentrations.

Sample Source or Type	Turbidity NTU	TSS mg/l	TDS mg/l	TPH mg/l	TKN mg/L	TP mg/L	Cond uS/cm
Influent median	14.5	98	36	4.23	0.5*	.244	26
Effluent median	15.0	26	40	2.12	0.5*	.204	29

Sample Source or Type	As ug/L	Cd ug/L	Cr ug/l	Cu ug/L	Pb ug/l	Zn ug/l	Cu dis. ug/L	Pb, dis. ug/l	Zn, dis. ug/l
Influent median	0.5*	0.5*	4.6	15.4	9.9	563.5	8.2	0.5*	434
Effluent median	0.5*	0.5*	2.5	10.4	5.9	494.0	6.0	0.8*	360

* indicates that more than one sample was below the method reporting limit.

Table 4. Median influent and effluent concentrations from six sampled storms.

Sample	Turbidity NTU	TSS mg/l	TDS mg/l	TPH mg/l	Cr ug/l	Pb ug/l	Zn ug/l	Diss Pb ug/l	Diss Zn ug/l
Influent	5.4-29	36-226	12-66	2.26-33.6	2-12.5	3.2-38.3	390-1230	0.5-1.8*	358-864
Effluent	2.5-28	16-210	5-156	0.25-4.68	0.5-8.3	0.5-24.3	345-828	0.5-1.6*	176-524

Table 5. Range of values for selected influent and effluent parameters from six sampled storms.

Percent Removals							
	02-Feb	03-May	13-Aug	06-Oct	26-Oct	18-Nov	Median
TPH	18	94	-6	62	36	91	49
As	-260	0	45	0	0	0	0
Cd	0	0	32	-180	0	0	0
Cr	75	9	33	17	0	74	25
Cu	35	19	-701	-6	15	67	17
Pb	88	34	37	29	5	82	36
Zn	-1	4	33	-44	8	42	6
Dis Cu	-4	1	38	42	38	-140	20
Dis Pb	0	0	-7	39	0	-160	0
Dis Zn	-1	-2	39	59		18	18
TDS	58	54	-234	-136	11	-33	-11
TSS	60	47	0	67	40	90	54
TKN	0	0	-40		3	0	0
TP	43	20	-31	-8	-5	30	8
Turb	12	54	-12	-19	15	31	14
Cond	-7	-12			-10	-8	-9

Table 6. Percent removal for individual sampled storms, and median percent removal for all storms.

Parameter	Turbidity	TSS	TDS	TPH	TKN	TP	Conductivity
Efficiency (%)	17	60	-10	67	-6	11	-9

Parameter	As	Cd	Cr	Cu	Pb	Zn	Diss Cu	Diss Pb	Diss Zn
Efficiency (%)	-12	-11	43	29	57	11	9	-9	27

Table 7. Efficiency (%) of Stormceptor[®] pollutant removal based on geometric mean of influent and effluent samples over six sampled storm periods. (Negative numbers indicate a net increase in a pollutant in the effluent stream)

The greatest median removal percentages were for TSS (54), TPH (49), and Total Pb (36). Overall efficiency based on the geometric mean influent and effluent concentrations was greatest for TPH (67 %), followed by TSS (60%) and Pb (57%). Median removal percentages for all remaining constituents ranged from -11 percent (TDS) to 25 percent (Cr), while efficiencies based on geometric mean for the remaining constituents ranged from -12 percent (As) to 43 percent (Cr). Negative numbers indicate that pollutant concentrations in the effluent stream were higher than in the influent water.

Sediment Testing Results

Attempts were made to sample sediment depth in the Stormceptor[®] on 1-February, 1999 and on 25-October, 1999, using a standard sludge bailer. No measureable sediment accumulation was found on either occasion. On the 25-October sampling date, a small amount of fine, dark black

particles and oily, organic-type residue was collected in the very bottom of the bailer. During these sampling events, staff could feel a hard bottom, assumed to be the concrete base of the Stormceptor®.

At the conclusion of the sampling program, sediment depth ranged from approximately 1-3 inches in the bottom of the Stormceptor®. Several one-gallon jars of sediment were collected after the water was pumped out of the Stormceptor®. Results from laboratory tests of sediment are shown in Table 8.

	As mg/kg	Cd mg/kg	Cr mg/kg	Pb mg/kg	Zn mg/kg	1-Chloro octadecane	Diesel range organics	Heavy oil hydrocarb.	% solids
Sediment	1.97	1.20	20.2	49.5	72.3	5.81 mg/kg	10,300 mg/kg	6,050 mg/kg	72

Table 8. Sediment Testing Results

Results of the particle size analysis are shown in Table 9. The largest percentage of particles by weight were in the 31.2-62.5 um range (36.3 %).

Sieve or hydrometer size (um)	Percent retained	Category	Category Total %
#4 (>4750)	4.6	pebbles	13.1
#10 (2000-4750)	8.5		
#20 (850-2000)	5.2		
#40 (425-850)	4.6		
#60 (250-425)	4.5		
#140 (106-250)	10.4		
#200 (75-106)	2.6		
#230 (62.5-75)	2.8	sand	30.1
phi 4-5 (31.2-62.5)	36.3		
phi 5-6 (15.6-31.2)	0		
phi 6-7 (7.8-15.6)	6.8	silt	53.3
phi 7-8 (3.9-7.8)	0		
phi 8-9 (1.95-3.9)	6.8		
phi 9-10 (0.98-1.95)	3.4		
phi 10+ (<0.98)	3.4	clay	3.4

Table 9. Sediment particle size distribution for sediment removed from Stormceptor®.

Draft APWA Protocol

Since the initiation of the Clark County project, a draft Protocol for the Acceptance of Unapproved Stormwater Treatment Technologies in the Puget Sound Watershed has been published for the Washington Chapter of the American Public Works Association (APWA), Stormwater Managers Committee. Upon review of that document, it is apparent the approach taken in the County's limited project was not equivalent to the newly designed protocol. Research on the order of that suggested by the new protocol would have considerably exceeded the scope and available budget for this project. Despite the differences in protocol, the results of the County study are briefly compared to the APWA approach as a general assessment of Stormceptor® performance.

Figures 3, 4, and 5 below are equivalence comparison guides from the newly developed protocol. They represent the "line of comparative performance" for evaluating unapproved BMPs in removing total suspended solids (TSS), total phosphorus (TP), and zinc, respectively. In order for a new technology to be deemed equivalent to an accepted BMP in the state manual, plotted values of influent concentration vs removal percentage should fall above and to the left of the line of comparative performance. In the case of TSS and Zinc, the new protocol suggests that 90% of plotted values should fall above and to the left of the line. In the case of TP, 80% should fall in that area.

Values from the Clark County Stormceptor® study have been superimposed on the figures for comparison.

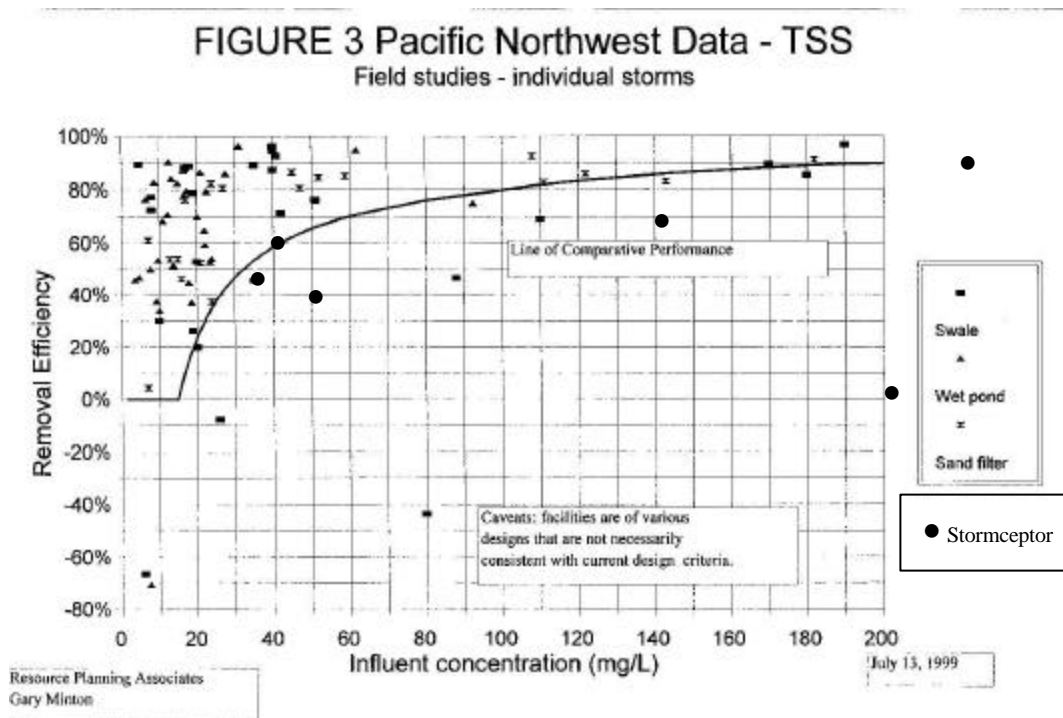


FIGURE 4 Pacific Northwest Data - TP
Field studies - individual storms

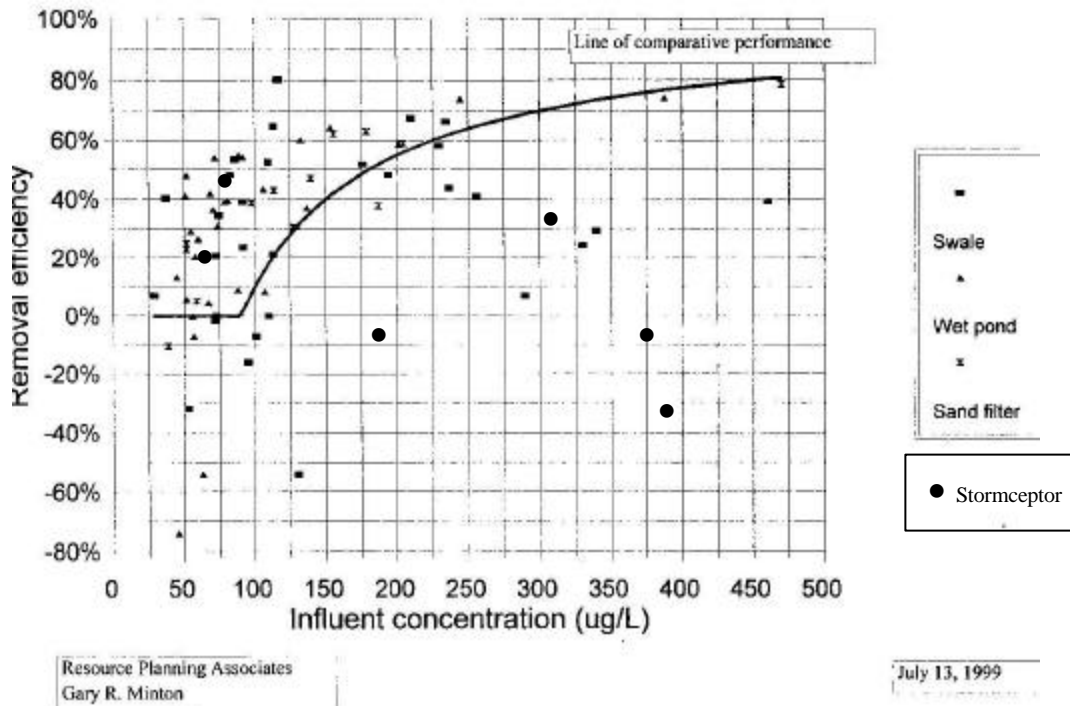
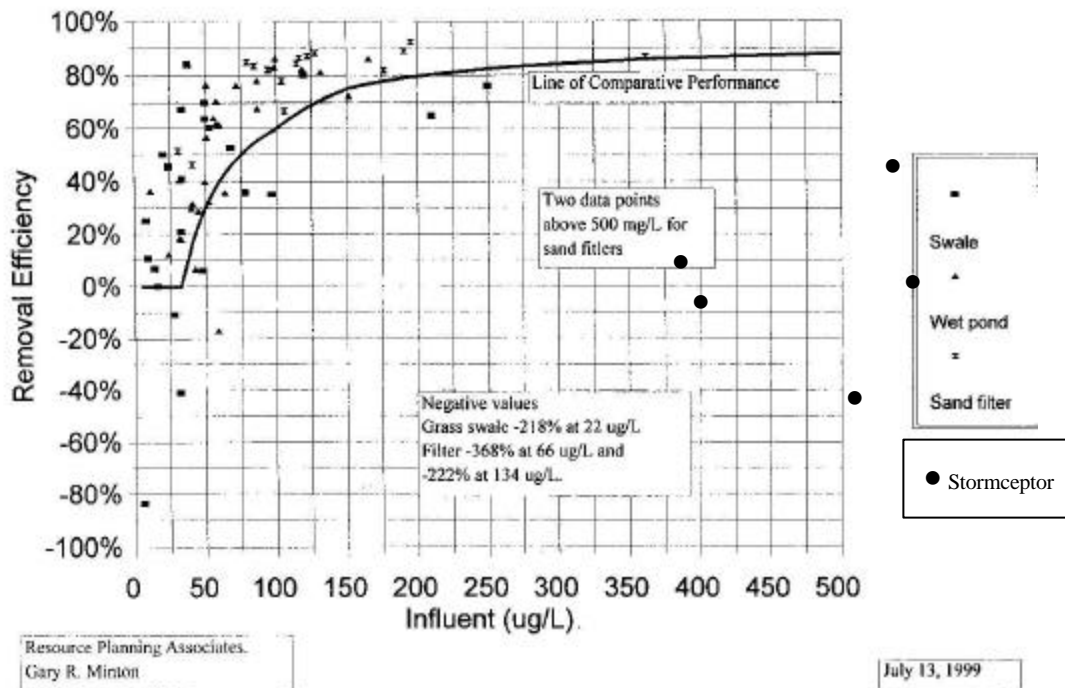


FIGURE 5 Pacific Northwest Data - Zinc
Field studies - individual storms



Most of the Stormceptor[®] data points plotted above fall significantly below the line of comparative performance for TSS, TP, and zinc, suggesting that, for this limited study, the performance of the Stormceptor[®] was not equivalent to the treatment we would expect with other previously approved BMPs.

Discussion

Data included in Appendix A and summarized in Table 4 suggest that some degree of removal was provided by the Stormceptor® for most parameters measured. However, much of that data is less than five times the detection limit for the given constituents and therefore may not give an accurate picture of removal. The APWA protocol calls for using only influent concentration data at least five times the detection limit for any given parameter.

Influent zinc concentrations were particularly high in several of the sampled storms. The source of this zinc is unknown, however possible sources in the study area could include shed roofs and various stockpiled equipment.

Loading calculations for the six sampled storms indicate that approximately 18 lbs of sediment should have been trapped in the Stormceptor® during those storms. The total rainfall during the 24-hour periods around those six storms was 2.31 inches. Total rainfall over the life of the project was approximately 28 inches. Based on a 50% removal rate, and assuming that sediment loading was reasonably correlated with rainfall, it seems plausible that over 200 lbs of sediment could have been trapped by the Stormceptor® over the course of the sampling period. Additional sediment should have been trapped during several preceding months when the Stormceptor® was in place but no testing was being performed.

Assuming that a cubic yard of sediment would weigh approximately 2000 lbs, then 200 lbs of sediment would be approximately 0.1 cubic yard or 2.7 cubic feet. Given an average depth of 0.1 feet of sediment in the Stormceptor® at the conclusion of the sampling program, this would equate to approximately 2.8 cubic feet of trapped sediment. The actual depth of sediment found in the Stormceptor® at the program conclusion appeared to average between 1-3 inches, suggesting that the actual amount of sediment retained was reasonable based on approximately 50% removal.

Conclusions

During this project, the Stormceptor[®] performed best for TSS, TPH, and Total Pb, with median removal percentages of 53.5, 49.0, and 35.5, respectively. Overall efficiency based on geometric means was greatest for TPH, TSS, and Pb, with efficiencies of 67, 60, and 57 percent, respectively. However, the level of removal for other parameters was considerably lower.

Given the limitations of the County sampling program and the differences between County and APWA testing protocol, it is not possible to draw strong conclusions from this project. In general, the results of this limited study suggest that the Stormceptor[®] may not provide equivalent treatment to standard treatment BMPs in the Washington Department of Ecology Stormwater Design Manual. Additional testing conforming to the APWA or other suitable testing protocol is necessary to adequately judge the effectiveness of the Stormceptor[®].

Overall, the Stormceptor[®] may be most suited for use as an initial or “pre-treatment” component of a treatment chain involving several BMPs, or possibly as a spill control device.

References

Claytor, R. A., April 1999, Performance of a Proprietary Stormwater Treatment Device – the Stormceptor[®], Technical Note 104: Watershed Protection Techniques, vol. 3, no. 1, p 605-608.

Turney, G.L., 1990, Quality of Groundwater in Clark County, Washington: U.S. Geological Survey Water Resource Investigation Report 90-4149, 97 p.

American Public Works Association, Washington Chapter, Stormwater Managers Committee. Draft Protocol for the Acceptance of Unapproved Stormwater Treatment Technologies in the Puget Sound Watershed, November 1999.

Appendix A- Data

February 1, 1999, Upstream Sample (Site 2)

Constituent	Conc.	Units	flow/sample in cf	#of samples	Load in mg	Load in kg
TPH	2.26000	mg/L	44	24	67587.4	0.07
Arsenic*	0.00050	mg/L	44	24	15.0	
Cadmium*	0.00050	mg/L	44	24	15.0	
Chromium	0.00200	mg/L	44	24	59.8	
Copper	0.00430	mg/L	44	24	128.6	
Lead	0.00410	mg/L	44	24	122.6	
Zinc	0.40500	mg/L	44	24	12111.9	0.01
Dissolved Copper	0.00240	mg/L	44	24	71.8	
Dissolved Lead*	0.00050	mg/L	44	24	15.0	
Dissolved Zinc	0.35800	mg/L	44	24	10706.3	0.01
TDS	12.00000	mg/L	44	24	358871.0	0.36
TSS	40.00000	mg/L	44	24	1196236.8	1.20
TKN*	0.50000	mg/L	44	24	14953.0	0.01
TP	0.07500	mg/L	44	24	2242.9	
Turbidity	7.5	NTU				
Conductivity	10.0	uS/cm				

*below reporting limit. Entered as 1/2 method reporting limit

February 1, 1999, Downstream Sample (Site 1)

Constituent	Comp. Conc.	Units	flow/sample in cf	#of samples	Load in mg	Load in kg
TPH	1.85000	mg/L	44	24	55326.0	0.06
Arsenic	0.00180	mg/L	44	24	53.8	
Cadmium*	0.00050	mg/L	44	24	15.0	
Chromium*	0.00050	mg/L	44	24	15.0	
Copper	0.00280	mg/L	44	24	83.7	
Lead*	0.00050	mg/L	44	24	15.0	
Zinc	0.41000	mg/L	44	24	12261.4	0.01
Dissolved Copper	0.00250	mg/L	44	24	74.8	
Dissolved Lead*	0.00050	mg/L	44	24	15.0	
Dissolved Zinc	0.36000	mg/L	44	24	10766.1	0.01
TDS*	5.00000	mg/L	44	24	149529.6	0.15
TSS	16.00000	mg/L	44	24	478494.7	0.48
TKN*	0.50000	mg/L	44	24	14953.0	0.01
TP	0.04290	mg/L	44	24	1283.0	
Turbidity	6.6	NTU				
Conductivity	10.7	uS/cm				

*below reporting limit. Entered as 1/2 method reporting limit

May 3, 1999, Upstream, Site 2

Constituent	Comp. Conc.	Units	flow/sample in cf	#of samples	Load in mg	Load in kg
TPH	4.03000	mg/L	44	24	120520.9	0.12
Arsenic*	0.00050	mg/L	44	24	15.0	
Cadmium*	0.00050	mg/L	44	24	15.0	
Chromium	0.00230	mg/L	44	24	68.8	
Copper	0.01080	mg/L	44	24	323.0	
Lead	0.00320	mg/L	44	24	95.7	
Zinc	0.60300	mg/L	44	24	18033.3	0.02
Dissolved Copper	0.00740	mg/L	44	24	221.3	
Dissolved Lead*	0.00050	mg/L	44	24	15.0	
Dissolved Zinc	0.48800	mg/L	44	24	14594.1	0.01
TDS	46.00000	mg/L	44	24	1375672.3	1.38
TSS	36.00000	mg/L	44	24	1076613.1	1.08
TKN*	0.50000	mg/L	44	24	14953.0	0.01
TP	0.06280	mg/L	44	24	1878.1	
Turbidity	5.4	NTU				
Conductivity	29.1	uS/cm				

*below reporting limit. Entered as 1/2 method reporting limit

May 3, Downstream, Site 1

Constituent	Comp. Conc.	Units	flow/sample in cf	#of samples	Load in mg	Load in kg
TPH*	0.25000	mg/L	44	24	7476.5	0.01
Arsenic*	0.00050	mg/L	44	24	15.0	
Cadmium*	0.00050	mg/L	44	24	15.0	
Chromium	0.00210	mg/L	44	24	62.8	
Copper	0.00870	mg/L	44	24	260.2	
Lead	0.00210	mg/L	44	24	62.8	
Zinc	0.57800	mg/L	44	24	17285.6	0.02
Dissolved Copper	0.00730	mg/L	44	24	218.3	
Dissolved Lead*	0.00050	mg/L	44	24	15.0	
Dissolved Zinc	0.49900	mg/L	44	24	14923.1	0.01
TDS	21.00000	mg/L	44	24	628024.3	0.63
TSS	19.00000	mg/L	44	24	568212.5	0.57
TKN*	0.50000	mg/L	44	24	14953.0	0.01
TP	0.05050	mg/L	44	24	1510.2	
Turbidity	2.5	NTU				
Conductivity	32.6	uS/cm				

*below reporting limit. Entered as 1/2 method reporting limit

Aug 13, 1999, Upstream, Site 2

Constituent	Comp. Conc.	Units	flow/sample in cf	#of samples	Load in mg	Load in kg
TPH	4.42000	mg/L	44	12	66092.1	0.07
Arsenic	0.00288	mg/L	44	12	43.1	
Cadmium	0.00190	mg/L	44	12	28.4	
Chromium	0.01250	mg/L	44	12	186.9	
Copper	0.03970	mg/L	44	12	593.6	
Lead	0.03830	mg/L	44	12	572.7	
Zinc	1.23000	mg/L	44	12	18392.1	0.02
Dissolved Copper	0.01030	mg/L	44	12	154.0	
Dissolved Lead	0.00150	mg/L	44	12	22.4	
Dissolved Zinc	0.86400	mg/L	44	12	12919.4	0.01
TDS	29.00000	mg/L	44	12	433635.8	0.43
TSS	211.00000	mg/L	44	12	3155074.6	3.16
TKN	2.84000	mg/L	44	12	42466.4	0.04
TP	0.39100	mg/L	44	12	5846.6	
Turbidity	25.0	NTU				
Conductivity	no data	uS/cm				

*below reporting limit. Entered as 1/2 method reporting limit

Aug 13, 1999, Downstream, Site 1

Constituent	Comp. Conc.	Units	flow/sample in cf	#of samples	Load in mg	Load in kg
TPH	4.68000	mg/L	44	12	69979.9	0.07
Arsenic	0.00157	mg/L	44	12	23.5	
Cadmium	0.00130	mg/L	44	12	19.4	
Chromium	0.00836	mg/L	44	12	125.0	
Copper	0.31800	mg/L	44	12	4755.0	
Lead	0.02430	mg/L	44	12	363.4	
Zinc	0.82800	mg/L	44	12	12381.1	0.01
Dissolved Copper	0.00635	mg/L	44	12	95.0	
Dissolved Lead	0.00160	mg/L	44	12	23.9	
Dissolved Zinc	0.52400	mg/L	44	12	7835.4	0.01
TDS	97.00000	mg/L	44	12	1450437.1	1.45
TSS	210.00000	mg/L	44	12	3140121.6	3.14
TKN	3.97000	mg/L	44	12	59363.3	0.06
TP	0.51100	mg/L	44	12	7641.0	
Turbidity	28.0	NTU				
Conductivity	no data	uS/cm				

*below reporting limit. Entered as 1/2 method reporting limit

Oct 6, 1999, Upstream, Site 2

Constituent	Comp. Conc.	Units	flow/sample in cf	#of samples	Load in mg	Load in kg
TPH	6.36000	mg/L	44	12	95100.8	0.10
Arsenic*	0.00050	mg/L	44	12	7.5	
Cadmium*	0.00050	mg/L	44	12	7.5	
Chromium	0.00630	mg/L	44	12	94.2	
Copper	0.02330	mg/L	44	12	348.4	
Lead	0.01290	mg/L	44	12	192.9	
Zinc	0.53100	mg/L	44	12	7940.0	0.01
Dissolved Copper	0.01090	mg/L	44	12	163.0	
Dissolved Lead	0.00180	mg/L	44	12	26.9	
Dissolved Zinc	0.43400	mg/L	44	12	6489.6	0.01
TDS	66.00000	mg/L	44	12	986895.4	0.99
TSS	146.00000	mg/L	44	12	2183132.2	2.18
TKN*	bad data	mg/L	44	12		
TP	0.37200	mg/L	44	12	5562.5	
Turbidity	16.0	NTU				
Conductivity	no data	uS/cm				

*below reporting limit. Entered as 1/2 method reporting limit

Oct 6, 1999, Downstream, Site 1

Constituent	Comp. Conc.	Units	flow/sample in cf	#of samples	Load in mg	Load in kg
TPH	2.39000	mg/L	44	12	35737.6	0.04
Arsenic*	0.00050	mg/L	44	12	7.5	
Cadmium	0.00140	mg/L	44	12	20.9	
Chromium	0.00520	mg/L	44	12	77.8	
Copper	0.02480	mg/L	44	12	370.8	
Lead	0.00920	mg/L	44	12	137.6	
Zinc	0.76600	mg/L	44	12	11454.0	0.01
Dissolved Copper	0.00630	mg/L	44	12	94.2	
Dissolved Lead	0.00110	mg/L	44	12	16.4	
Dissolved Zinc	0.17600	mg/L	44	12	2631.7	0.00
TDS	156.00000	mg/L	44	12	2332661.8	2.33
TSS	48.00000	mg/L	44	12	717742.1	0.72
TKN*	bad data	mg/L	44	12		
TP	0.40300	mg/L	44	12	6026.0	
Turbidity	19.0	NTU				
Conductivity	no data	uS/cm				

*below reporting limit. Entered as 1/2 method reporting limit

Oct 26, 1999, Upstream, Site 2

Constituent	Comp. Conc.	Units	flow/sample in cf	#of samples	Load in mg	Load in kg
TPH	1.38000	mg/L	44	24	41270.2	0.04
Arsenic*	0.00050	mg/L	44	24	15.0	
Cadmium*	0.00050	mg/L	44	24	15.0	
Chromium	0.00280	mg/L	44	24	83.7	
Copper	0.01410	mg/L	44	24	421.7	
Lead	0.00682	mg/L	44	24	204.0	
Zinc	0.39000	mg/L	44	24	11663.3	0.01
Dissolved Copper	0.00900	mg/L	44	24	269.2	
Dissolved Lead*	0.00050	mg/L	44	24	15.0	
Dissolved Zinc	no data	mg/L	44	24		
TDS	36.00000	mg/L	44	24	1076613.1	1.08
TSS	50.00000	mg/L	44	24	1495296.0	1.50
TKN	1.16000	mg/L	44	24	34690.9	
TP	0.18300	mg/L	44	24	5472.8	
Turbidity	13.0	NTU				
Conductivity	44.1	uS/cm				

*below reporting limit. Entered as 1/2 method reporting limit

Oct 26, 1999, Downstream, Site 1

Constituent	Comp. Conc.	Units	flow/sample in cf	#of samples	Load in mg	Load in kg
TPH	0.88800	mg/L	44	24	26556.5	0.03
Arsenic*	0.00050	mg/L	44	24	15.0	
Cadmium*	0.00050	mg/L	44	24	15.0	
Chromium	0.00280	mg/L	44	24	83.7	
Copper	0.01200	mg/L	44	24	358.9	
Lead	0.00649	mg/L	44	24	194.1	
Zinc	0.35800	mg/L	44	24	10706.3	0.01
Dissolved Copper	0.00560	mg/L	44	24	167.5	
Dissolved Lead*	0.00050	mg/L	44	24	15.0	
Dissolved Zinc	no data	mg/L	44	24		
TDS	32.00000	mg/L	44	24	956989.4	0.96
TSS	30.00000	mg/L	44	24	897177.6	0.90
TKN	1.13000	mg/L	44	24	33793.7	0.03
TP	0.19300	mg/L	44	24	5771.8	
Turbidity	11.0	NTU				
Conductivity	48.5	uS/cm				

*below reporting limit. Entered as 1/2 method reporting limit

Nov 18, 1999, Upstream, Site 2

Constituent	Comp. Conc.	Units	flow/sample in cf	#of samples	Load in mg	Load in kg
TPH	33.60000	mg/L	44	24	1004838.9	1.00
Arsenic*	0.00050	mg/L	44	24	15.0	
Cadmium*	0.00050	mg/L	44	24	15.0	
Chromium	0.00770	mg/L	44	24	230.3	
Copper	0.01670	mg/L	44	24	499.4	
Lead	0.02940	mg/L	44	24	879.2	
Zinc	0.59600	mg/L	44	24	17823.9	0.02
Dissolved Copper*	0.00100	mg/L	44	24	29.9	
Dissolved Lead*	0.00050	mg/L	44	24	15.0	
Dissolved Zinc	0.36400	mg/L	44	24	10885.8	0.01
TDS	36.00000	mg/L	44	24	1076613.1	1.08
TSS	226.00000	mg/L	44	24	6758737.9	6.76
TKN*	0.50000	mg/L	44	24	14953.0	0.01
TP	0.30500	mg/L	44	24	9121.3	0.01
Turbidity	29.0	NTU				
Conductivity	23.2	uS/cm				

*below reporting limit. Entered as 1/2 method reporting limit

Nov 18, 1999, Downstream, Site 1

Constituent	Comp. Conc.	Units	flow/sample in cf	#of samples	Load in mg	Load in kg
TPH	3.05000	mg/L	44	24	91213.1	0.09
Arsenic*	0.00050	mg/L	44	24	15.0	
Cadmium*	0.00050	mg/L	44	24	15.0	
Chromium	0.00200	mg/L	44	24	59.8	
Copper	0.00550	mg/L	44	24	164.5	
Lead	0.00540	mg/L	44	24	161.5	
Zinc	0.34500	mg/L	44	24	10317.5	0.01
Dissolved Copper	0.00240	mg/L	44	24	71.8	
Dissolved Lead	0.00130	mg/L	44	24	38.9	
Dissolved Zinc	0.29800	mg/L	44	24	8912.0	0.01
TDS	48.00000	mg/L	44	24	1435484.2	1.44
TSS	22.00000	mg/L	44	24	657930.2	0.66
TKN*	0.50000	mg/L	44	24	14953.0	0.01
TP	0.21400	mg/L	44	24	6399.9	0.01
Turbidity	20.0	NTU				
Conductivity	25.1	uS/cm				

*below reporting limit. Entered as 1/2 method reporting limit